Infant Responding Compared Under Conjugate- and Continuous-Reinforcement Schedules

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The performance of six human infants (aged 16 to 20 weeks) was compared under a conjugate- versus a continuous-reinforcement schedule. The contingent visual stimulus, a sequence of 5 colored lights, their intensity varying in proportion to response amplitude under the conjugate but not under the continuous schedule, was presented alone and together with a constant auditory contingent stimulus—chimes placed behind the lights—under both schedules. The target operant response—a foot press of a vertical panel—produced the lights with/without the tinkling chimes. A reversal design counterbalanced with alternating treatments was implemented for each half of the participants. Visual inspection of the graphed-operant frequencies for all six infants, and one-tail binomial tests, showed at $p < 0.008$ that: (a) the two contingent-stimulus complexes, visual alone and visual-plus auditory, functioned as reinforcers of leg thrusts under both reinforcement schedules; the visual-plus-auditory consequence was a more effective reinforcer for leg-thrust operants than was the visual consequence alone; and, (c) compared to the continuous CRF schedule, the conjugate-reinforcement schedule generated higher peak responding.

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In operant learning, *reinforcement* is defined as the process in which a behavior unit can more likely recur as a result of the positive consequences it produces. Ferster and Skinner (1957) described four basic types of intermittent-reinforcement schedules: fixed ratio, variable ratio, fixed interval, and variable interval. Different patterns and rates of responses have resulted when behavior units/operant responses have been subjected to different reinforcement-contingency schedules. Almost all work on reinforcement to date has involved preparations in mammals using free-operant procedures in which operant classes are followed on some schedule by narrowly-defined classes of stimulus consequences (reinforcers), but with no other dependent relation between operant and consequence. Also, the features of the operant and the reinforcer class have remained constant in each research demonstration, features that ordinarily vary along diverse dimensions in life settings.

A *continuous*-reinforcement schedule (CRF) denotes a pattern according to which every narrowly-defined response instance is followed by a narrowly-defined consequence. A *conjugate*-reinforcement schedule departs from traditional reinforcement schedules with homogeneous consequences in that an attribute of its consequence (e.g., amount, size, consistency) is *proportional* to the rate, intensity, or duration of responding (Lindsley, 1957, 1963; Lipsitt, 1967).

In a schedule of reinforcement termed "synchronous," similar in effects to those associated with conjugate reinforcement, the onset and offset of each participant's response is in temporal synchrony with onset and offset of the reinforcer (Pelaez-Nogueras, Gewirtz, Field, Cigales, Malphurs, Clasky, & Sanchez, 1996; Pelaez-Nogueras, Field, Gewirtz, Cigales, Gonzales, Sanchez, & Clasky, 1997; Ramey, Hieger, & Klisz, 1972). The synchronized reinforcement operation used by Pelaez et al. (1996, 1997) is a contingency-based operant procedure that permitted comparison in the reinforcing effectiveness of types of adult stimulation (auditory, visual, tactile) in maintaining infant behavior. The procedure also allowed demonstration that caregiver touch can control infant eye contact, smiling, vocalization, and can establish the functional relation between reinforcing stimulation and diverse infant operants.

Continuous Reinforcement Research

There is a vast body of literature on operant learning in animals and humans, with most of the work having used a discrete delivery of reinforcers. Continuous reinforcement denotes a discrete delivery of a more or less constant reinforcing stimulus in that each response produces an instance of that reinforcer. Continuous reinforcement (CRF) is the most basic of schedules, leading to rapid increases in response rate (i.e., acquisition of the particular behavior unit).

It is well established in the operant-learning literature, primarily from animal experimentation, that CRF schedules generate the rapid acquisition of new behaviors, and numerous studies have demonstrated its effectiveness in behavioral acquisition with humans as well. Etzel and Gewirtz (1967) used a CRF schedule of reinforcement to reverse the problem-crying behavior of one-month infants . Similarly, Bloom (1974, 1975; Bloom & Esposito 1975), and Wahler (1967) demonstrated the efficacy of social reinforcers for the behavior of 3-month-old humans. Silverstein (1972) and Silverstein and Lipsitt (1974) used continuous reinforcement with 10-month-old humans in a spatial discrimination task to demonstrate the effect of secondary reinforcement and to produce a subsequent spatial preference on the part of the participants.

The continuous-reinforcement schedule has been extended to the investigation of learning and emotional responsivity of infants who were exposed to cocaine *in utero* (Alessandri, Sullivan, Imaizumi, & Lewis, 1993), to infants developing verbal behavior for several response classes over a one-year period (Wahler, 1969), and to the shaping of self-initiated toileting in infants (Smeets, Lancioni, Ball, & Oliva, 1985).

Conjugate Reinforcement Research

Among the first to use the free-operant model with humans, Lindsley (1957) coined the term "conjugate reinforcement" to label how a reinforcer attribute (rate, duration, or intensity) can become associated with some response attribute. Mira (1968) used the conjugate reinforcement paradigm to analyze patterns of looking and listening preferences among children, with the rate of responding on a hand switch controlling the intensity of a continuously available consequence. Mira (1970) later researched the rate at which hearing-impaired school-aged children responded to audio narrations and the varying ways in which they responded to the opportunity to listen. The use of conjugate reinforcement was extended to the investigation of verbal narrative preferences of children (Lovitt, 1967a; 1967b; 1968a). Similarly, Lovitt (1968b) researched the musical preferences of children. Participants were provided with a hand switch to select continuously the music of their choice by either pressing or not pressing the switch.

Lipsitt, Pederson, and DeLucia (1966) were among the first to use a conjugate schedule in the study of infant learning. Seated in front of a dark screen, 12-month-old infants could press with either one or both hands a panel to illuminate and view a stimulus on the screen. Reinforcement (the viewing in focus of a colorful image of a clown) was provided proportional to the infants' response rate.

A direct outgrowth of Lindsley's work was Siqueland's and DeLucia's (1969) development of a high-amplitude sucking procedure. Infants' sucking response that exceeded a predetermined amplitude threshold was reinforced in intensity proportionally to the rate of responses. Other researchers of infant learning, memory, and perception have used a similar procedure (Lipsitt, 1966; Spence, 1996). Lindsley (1963) used a conjugate-reinforcement procedure with a five-month-old human to investigate the efficacy of social reinforcers produced by the increased rate of kicking to produce the reinforcing event (a silent movie of a smiling female). Rovee and Rovee (1969) used conjugate reinforcement produced by an overhead mobile connected without slack via ribbon to infants' left ankles. The rate and amplitude of infant leg-movement instances resulted in the mobile's figures swaying and colliding proportionately to the responses. Because of its simplicity and ease of implementation, the mobile's movements that provided conjugate reinforcement for the leg kick sparked a flurry of investigations of infant learning and memory. Thus was studied the effects of quantitative shifts in visual reinforcers on operant responses (Fagen & Rovee, 1976); the positive behavioral contrast in 3-month-olds (Rovee-Colier & Capatides, 1979); the efficacy of auditory and visual conjugate reinforcement in conditioning (Mc Kirdy & Rovee, 1978); the conditioning of long-term memory (Sullivan, Rovee-Collier & Tynes, 1979); the reactivation of memories in early infancy (Fagen, Yengo, Rovee-Collier & Enright, 1981, Hitchcock & Rovee-Collier, 1996; Rovee-Collier, Enright, Lucas, Fagen & Gekoski, 1981; Rovee-Collier & Hayne, 1987); learning and memory in pre-term infants (Gekoski, Fagen & Pearlman, 1984); the amount of training and retention by infants (Ohr, Fagen, Rovee-Collier, Hayne & Linde, 1989); long-term maintenance of infant memory (Rovee-Collier, Hartshorn & Manda, 1999); encoding and retrieval of infant memory (Hartshorn & Rovee-Collier, 2003); conditioning and long-term memory in three-month-olds with Down syndrome (Ohr & Fagen, 1991); and memory processing of a serial list by young infants (Gylya, Rovee-Collier, Gallucio & Wilk, 1986). In all of the aforementioned studies, the conjugate-reinforcement procedure was associated with maintaining high and steady response rates for lengthy time periods.

The notion that the infant is an incomplete organism who gradually performs higher levels of accomplishment defined in terms of adult behavior (White, 1959) no longer appears tenable. In contrast, Rovee-Collier and Gekoski (1979) proposed that the human infant is simply a different organism who occupies an ecological niche that departs from that of adults. Therefore it is possible that infants learn the contingencies of conjugate reinforcement more readily because the schedule is analogous to the situations controlling their development in their ecological niche. In the natural environment, for example, when an infant cries, the frequency and loudness of the cry may prompt the mother to approach more rapidly, or the amount of milk obtained by a sucking baby may be proportionate to the pressure and the frequency of each suck.

Lindsley developed the conjugate schedule to handle situations in which continuity is often interrupted and the reinforcing efficacy is compromised when the stimulus is turned off by discrete reinforcement schedules (variable interval, fixed interval, variable ratio, fixed ratio). Lindsley contended that this schedule is the most basic and fundamental, particularly for humans with incomplete or impaired cortical functioning (e.g., infants, individuals with presumed minimal brain damage, psychotics, and mental retardates). The schedule appears to have ecological significance because it closely resembles the way in which the aforementioned organisms learn what contingencies operate in the natural environment.

Synchronized Reinforcement Procedure

Similar to the conjugate reinforcement procedure is the synchronized reinforcement procedure developed by Pelaez-Nogueras et al. (1996). This is a contingency-based operant procedure that specifically allows the experimenter to compare the reinforcing efficacy of different types of adult stimulation in maintaining infant behavior. It permits a systematic comparison of the effects of different adult compound stimuli (e.g., auditory, visual, tactile) alternated during face-to-face interactions. The procedure allows the experimenter systematically to demonstrate that caregiver touch can regulate infant state (attention) as well as control infant positive affect (denoted by smiles and vocalizations). During extinction, in the absence of auditory stimuli and changes in maternal facial expression, the rate of infant response is expected to decrease, thus demonstrating a functional relation between the reinforcing tactile stimulation and the infant behavior.

Using this synchronized reinforcement procedure, Pelaez et al. (1996) compared the effect of an adult stimulus compound treatment that included touch with the effect of an adult stimulus compound treatment that did not include touch (only auditory and visual stimuli) on infant behavior during face-to-face interactions.

The results demonstrated that a social stimulus compound that included touching the infants functioned as a more effective reinforcer for infant eye-contact behavior than a stimulus compound that did not include touch.

While the traditional approaches have permitted researchers to investigate many phenomena with infants (e.g., habituation), these have had their limitations. Because infant attention span is fluctuating and short, experimental sessions with them are usually brief in order to reduce subject attrition (Hulsebus 1973). While brevity of experimental sessions insures that the infant is kept alert and interested, it may prevent experimenters from measuring fully the impact of the independent variable on dependent measures (Pomerleau & Malcuit, 1992). On the other hand, an operant task, such as the synchronized reinforcement procedure, appears to be more amenable in maintaining responding on the part of the participants being tested.

In summary, the study being reported had a dual objective. First, it would permit a direct comparison of two different reinforcement schedules, both on a one-to-one fixed ratio (FR1). Second, the study would enable the experimenter to compare various measures of responding (frequency, intensity, or duration) of the target behavior emitted under the continuous-reinforcement schedule with measures of responding emitted under the conjugate-reinforcement schedule, where the infant participant would have a greater degree of control of his or her own stimulation.

Research Hypotheses

The *first* hypothesis was that operant learning would occur: that the presentation of a contingent visual stimulus alone, followed by a contingent visual-plus-auditory stimulus complex, would *both* reinforce infant leg-thrust responses. Consequently, a pattern of zero-slope responding during *baseline* phases of positive-slope responding during reinforcement phases, and of negative-slope responding during reversal phases, was expected in the graphed-response pattern of each participant. This conditioning hypothesis was a corollary of the sequential contingencies functioning as positive reinforcers for the leg-thrust operant. The *second* hypothesis was that, compared to responding producing the visual-stimulus alone, responding producing the consequence of the visual-plus-auditory stimulus complex would result in a higher rate, particularly under the conjugate schedule. The *third* hypothesis was that the visual-plus-auditory stimulus complex, of greater reinforcer efficacy for leg-thrust operants with a higher response level under conjugate reinforcement, would provide clear evidence of a difference between the conjugate- and the continuous-reinforcement schedules. Because the auditory stimulus would be presented as a constant and in the same order to all participants, change in responding could be attributed largely, if not solely, to the visual stimulus. Thus, the third hypothesis was that the visual-plus-auditory stimulus complex, of greater reinforcer efficacy for leg-thrust operants with a higher response level under conjugate reinforcement, would provide clear evidence of a difference between the conjugate and the continuous reinforcement schedules. Responding during the presentation of visual-auditory stimuli would result in a higher rate than during the presentation of visual-stimulus consequences alone, particularly when participants' responding was reinforced under a conjugate schedule.

Method

Participants

Eleven human infants (4 boys, 7 girls) between the age of 16 and 20 weeks participated in this study. They were recruited by word of mouth, from nurseries, and from the Office of Vital Records in Miami-Dade County, independent of such demographic variables as ethnicity, "race," socioeconomic status, or gender. Parents were acquainted with the purpose of the study, and signed an informed consent form denoting their agreement to permit their infants' participation. The requirement for eligibility was that potential participants were full-term healthy infants with a normal birth and no medical or neurological problems.

The criteria to stop sampling during treatment phases were as follows: (1) the last 2 data points should not differ by more than 3 units, (2) the last 2 data points should be part of an ascending trend and (3) the rate of responding at the end of the treatment phases should be at least 3 times the average rate of responding of the last 3 data points of the baseline condition. As for the reversal conditions, the criteria to cease sampling were that data points should depict a descending trend, if possible, to the mean responding level in the baseline condition.

Not all data collected for the participants are reported: two infants participated only in the study's exploratory phase; two infants were disqualified because they exhibited an excessive fussiness (i.e., fussing/crying continuously) when placed under an experimental condition; and one did not perform to criterion on the operant task. The responding of the residual 6 infants, who were exposed to the entire experimental procedure, are graphically reported (see Fig. 1-6).

Apparatus and Stimuli

Participants were tested in their homes. Each infant was seated in an infant seat placed in an enclosure (46 cm wide, 81 cm long, and 20 cm high), with feet facing a vertical panel (41 cm wide, and 33 cm high) which was kept in place by a spring calibrated from 0 to 2,500 g. The visual consequence of the leg kick consisted of 5 colored 12-volt 5-watt lights serially connected. When following the visual, the auditory chimes consequence was produced by 5 metal pipes (15 cm long, 1 cm in diameter) that hung vertically by way of strings and a metal bar (9 cm in length, 0.50 cm in diameter) that hung horizontally via strings as well. Each press of the panel lit the series of five 5-watt lights (orange, yellow, green, blue, violet) that provided the putative visual reinforcer, or produced a tinkling metallic sound resulting from the chimes being struck by a wooden hammer protruding from the back of the vertical panel, in conjunction with lighting the series of colored lights.

Because of the necessity of comparability when presenting the visual stimulus to the participants under both schedules of reinforcement, the brightness of the light when presented discretely was powered by 6 rather than 12 volts (mid-illumination) and was kept constant regardless of the rate or intensity of responding. Under the conjugate-schedule presentation, however, the brightness of the lights was programmed to fluctuate linearly from the dimmest (1-g pressure) to the brightest illumination (2500-g pressure). A leg thrust that caused any displacement of the panel, and the onset of the contingent visual with/without auditory stimulus, scored a response.

Design

The experiment was conducted using a single-subject reversal design (A-B-A-C-A for 3 participants and A-C-A-B-A for 3 participants), with 2 alternating treatments across phases (Barlow & Hayes, 1979). The phases encompassed baseline or reversal conditions (A), continuous reinforcement (B), and conjugate reinforcement (C) were implemented in two orders, but (B) and (C) phases were counterbalanced between the two halves of the participants. The first phase (A) in the sequence denoted the *baseline* control condition. The subsequent (A) phases referred to non-reinforcement reversals and were implemented to minimize the possibility of finding a carryover effect. The (B) and (C) conditions were counterbalanced across participants to control for sequential confounding.

Procedure

Each session lasted from 12 to 20 min, and began with establishing that the infant was on schedule (i.e., fed, diapered, and not sick). If an infant cried for more than 5 sec on an occasion, a halt was enacted and the parent or present caretaker was directed to comfort the child. The experimental sessions were held in abeyance if the infants were not attending to the visual stimuli for more than 10 sec. If an infant cried continuously for more than 25 sec, in spite of a parent's effort to comfort him/her, the session was terminated for that day. Each infant was tested at the time of the day the caregiver indicated to be the infant's alert or play period.

Ideally, collecting the data across all conditions in one session would have better served the purpose of this investigation, but doing so would have required participants' cooperation for at least 50 consecutive min. During the exploratory phase of the study, two participants could not tolerate being in the experimental condition for an entire session of 50 min, and the intolerance became even more apparent when other participants were subsequently tested. Consequently, the data collection was divided into as many sessions as were required over several days until each participant served in all phases of the experiment.

Baseline. The caregiver seated the participant in the seat with side partitions in place so that the infant faced the vertical panel and the unlit colored lights. No consequences (visual or auditory) were presented to the participant when s/he pressed the panel. After establishing that a stable baseline was manifested (zero slope), the first treatment (continuous or conjugate reinforcement) was implemented.

Continuous reinforcement. Each time the infant foot pressed the panel, irrespective of response intensity, the colored lights turned on simultaneously for a duration of 100 ms. After at least 5 min of such visual presentations, the visual-auditory presentation was effected for a duration of at least 5 min. The presentation of the visual stimulus under either schedule always preceded that of both stimuli in combination (visual plus auditory).

Conjugate reinforcement. During the conjugate reinforcement schedule, each foot press of the panel produced the visual stimulus. The vigor with which participants pressed the panel was directly proportional to the brightness of the contingent colored lights produced. The engagement of the panel (i.e., the duration of a response) always resulted in the presentation of the visual consequence, and forward displacement of the panel resulted in the brightness of the colored lights. The visual-plus-auditory consequence series always followed that of the visual-consequence alone series, and data collection lasted at least 5 min in each phase.

Reversal. During the reversal phases, no consequence (visual or visual plus auditory) was presented. Participants remained seated in the enclosure with the side partitions in place, and could press the panel. Data were collected until participants' rate of responding had dropped to a level approaching that of the baseline condition.

Coding of Responses and Interobserver Agreement

Two individuals, who were instructed by the principal researcher on what constituted a response, independently coded the occurrence of responding in all phases for three participants chosen at random (50% of the data). The definition of a response was unequivocal: any forward displacement of the calibrated spring, even when the displacement did not originate from zero on the 0-2500 gram range, denoted a response. The interobserver reliability focused specifically on the frequency of occurrence of the target behavior (panel displacement resulting from leg thrust). Because the rate (frequency/time) of responding was easier to ascertain than any other behavioral dimension (i.e., amplitude or duration), the examiners were instructed simply to count the forward displacements of the calibrated spring from videotaped sessions with participants.

Interobserver reliability was calculated for each participant and for all phases by dividing the smaller frequency of occurrence reported, either by the principal investigator or the reviewers, by the larger frequency of occurrence reported for each phase and multiplying by 100. The percentage of agreement of all phases was aggregated and divided by the number of phases to arrive at the interobserver agreement. Thus, the interobserver agreement was 94% for one-half of the data.

Results

Data for the behavior pattern of infants who successfully completed every phase of the study were graphed. Figures 1 to 6 represent the participants' operant responding. Although videotaping the calibrated spring provided enough information for participants' responding to be measured in terms of many behavioral attributes (i.e., rate, response amplitude, response duration), the primary responding assessment was of participant response rate because that was the simplest of the response attributes for the independent reviewers to code. Each data point depicts responding in successive one-minute blocks for each participant.

In this frame, the data analysis consists of the visual inspection across all experimental phases to identify trends within and between subjects, and then to make the direct comparison among the various treatments (visual vs. visual-plus-auditory; conjugate vs. continuous reinforcement). That (B) or (C) condition occurred first or second was ignored. The hypotheses that were tested follow: (1) the visual and auditory stimuli would function as reinforcers, singly or combined; (2) the visual stimulus, because of its ease of manipulation, would evidence the dissimilarity between the two schedules of reinforcement, and (3) the pairing of visual and auditory modalities would differ, or possibly result in higher rates of responding than when the visual consequences were presented alone.

Fig. 1 Response frequency of infant participant #1 during four successive sessions.

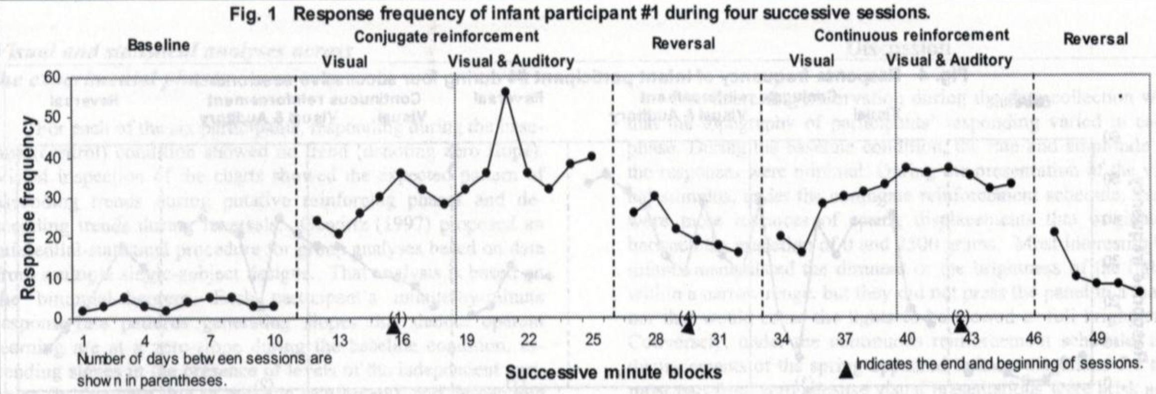


Fig. 2 Response frequency of participant #2 during four successive sessions.

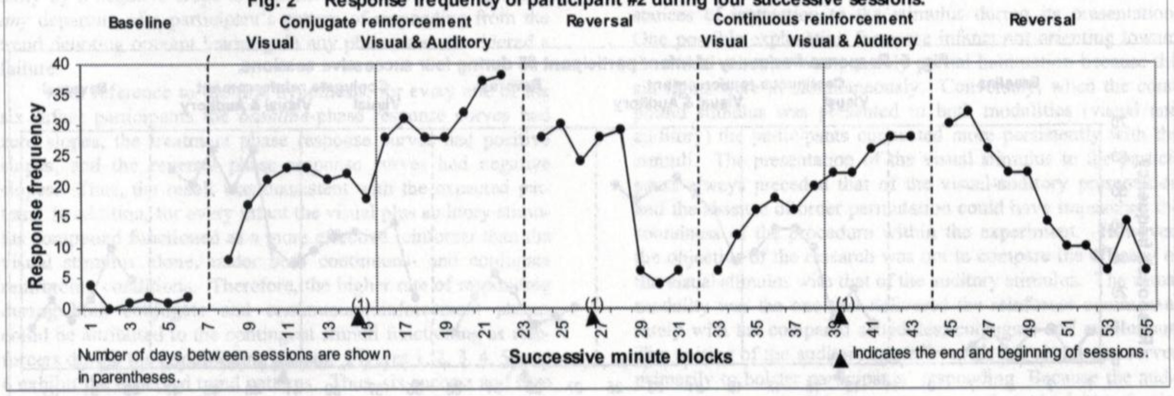


Fig. 3 Response frequency of infant participant #3 during successive sessions.

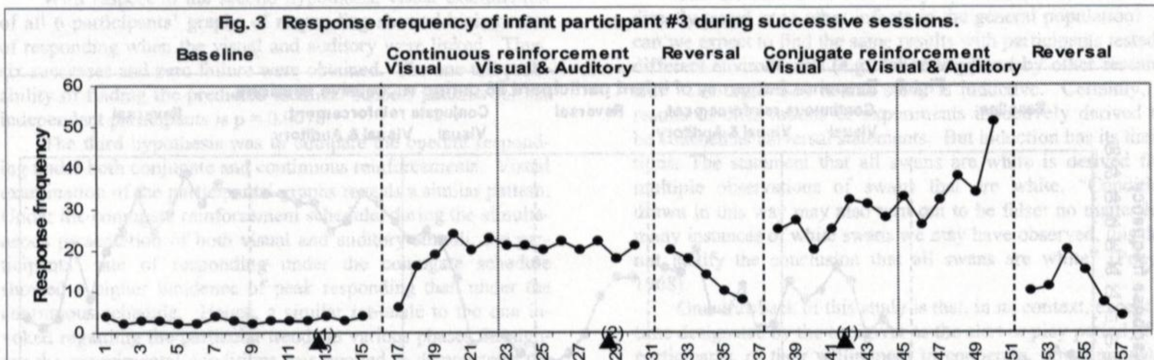


Fig. 4 Response frequency of infant participant #4 during four successive sessions.

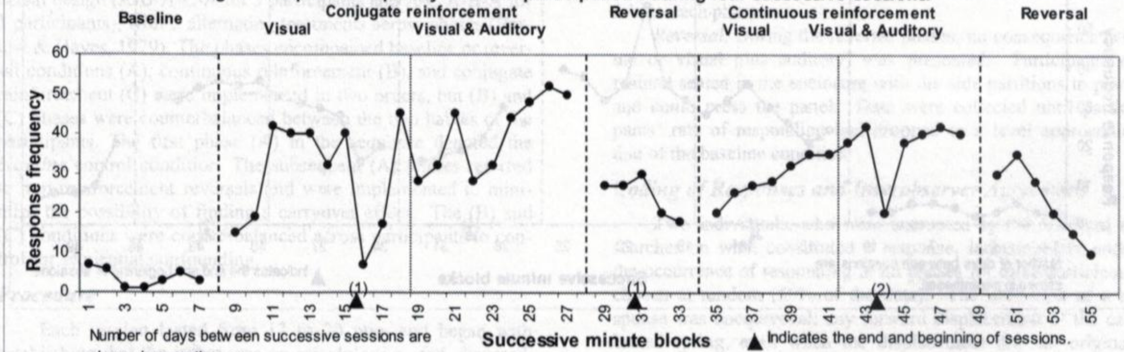


Fig. 5 Response frequency of infant participant #5 during four successive sessions.

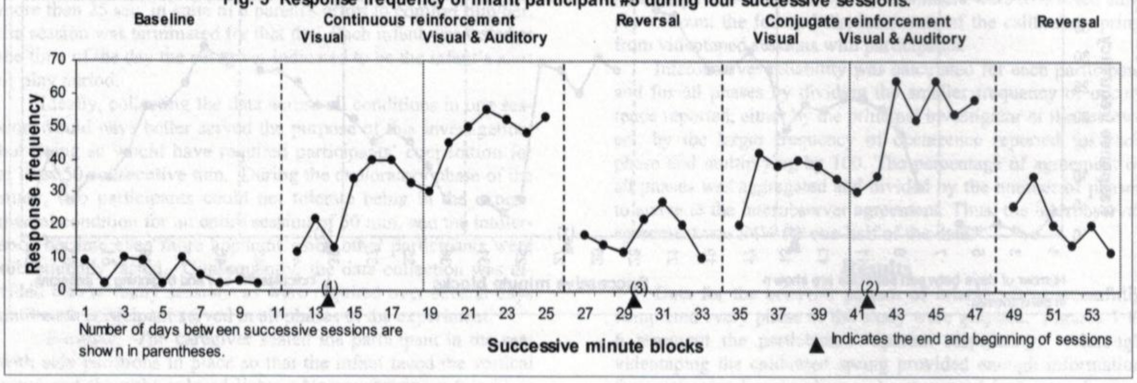
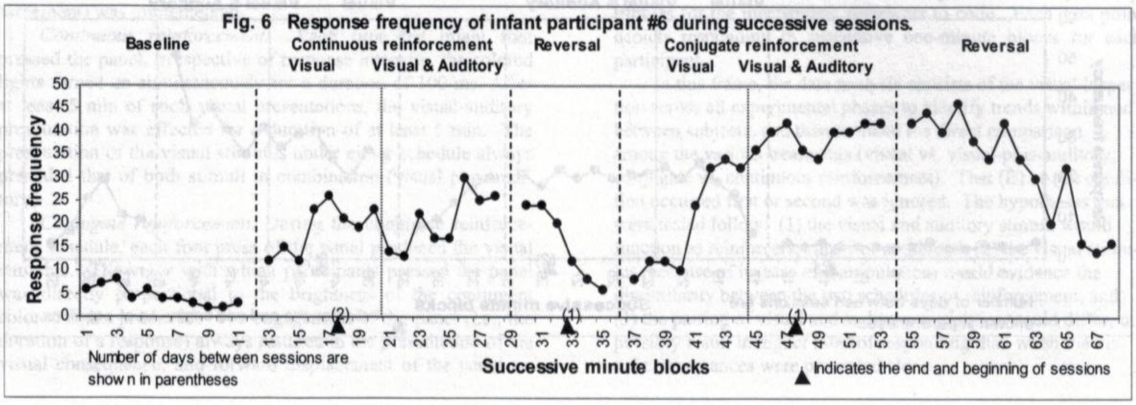


Fig. 6 Response frequency of infant participant #6 during successive sessions.



Visual and statistical analyses across the experimental phases

For each of the six participants, responding during the baseline (control) condition showed no trend (denoting zero slope). Visual inspection of the charts showed the expected pattern of ascending trends during putative reinforcing phases and descending trends during reversals. Gewirtz (1997) proposed an inferential-statistical procedure for group analyses based on data from multiple single-subject designs. That analysis is based on the binomial-theorem. Each participant's minute-by-minute response-rate patterns generating slopes that denote operant learning are at a zero-slope during the baseline condition, ascending slopes in the presence of levels of the independent variables (in this case due to putative reinforcers), and descending slopes when the reinforcers are eliminated during reversal treatments. Thus, for each participant a five-phase response pattern in which a zero slope is followed by a positive slope that, in turn, is followed by a negative slope, a positive slope, and finally by a negative slope is considered a success. Conversely, *any* departure of a participant's pattern of responding from the trend denoting operant learning, in any phase, was considered a failure.

With reference to the first hypothesis, for every one of the six infant participants the *baseline*-phase response curves had zero slopes, the treatment phase response curves had positive slopes, and the reversal phase response curves had negative slopes. Thus, the result was consistent with the expected pattern. In addition, for every infant the visual plus auditory stimulus compound functioned as a more effective reinforcer than the visual stimulus alone, under both continuous- and conjugate reinforcing conditions. Therefore, the higher rate of responding during both conjugate and continuous-reinforcement phases could be attributed to the contingent stimuli functioning as reinforcers during the conditioning phases. Figures 1, 2, 3, 4, 5, and 6 exhibit the expected trend patterns. Thus, six success and zero failure patterns were obtained. The one-tail probability of finding six success patterns for six independent participants is $p = 0.0078$.

With respect to the second hypothesis, visual examination of all 6 participants' graphs of responding showed higher rates of responding when the visual and auditory were linked. Thus, six successes and zero failure were obtained. The one-tail probability of finding the predicted identical success patterns for six independent participants is $p = 0.0078$.

The third hypothesis was to compare the operant responding under both conjugate and continuous reinforcements. Visual examination of the participants' graphs reveals a similar pattern. Under the conjugate reinforcement schedule, during the simultaneous presentation of both visual and auditory stimuli, the participants' rate of responding under the conjugate schedule showed a higher incidence of peak responding than under the continuous schedule. Hence, a similar rationale to the one invoked regarding the particular trends in various phases throughout the experimental conditions was applied to demonstrate the consistent trend in six independent cases. The one-tail probability of finding six (success) patterns of higher responding during conjugate than under continuous reinforcement in six participants is $p = 0.0078$ (one tail).

Discussion

One interesting observation during the data collection was that the topography of participants' responding varied in each phase. During the baseline condition, the rate and amplitude of the responses were minimal. During the presentation of the visual stimulus, under the conjugate reinforcement schedule, there were more instances of spring displacements that originated between the gradation of 0 and 2500 grams. Most interestingly, infants manipulated the dimness or the brightness of the lights within a narrow range, but they did not press the panel in a manner that would cause the lights to be viewed at full brightness. Conversely, under the continuous reinforcement schedule, the displacements of the spring appeared to have originated for the most part from zero because visual presentations were brisk and discrete. Participants, under that schedule, exhibited fussiness and displeasure.

Contrary to the expectation that participants in performing the operant task would sustain a prolonged interest in the presence of the visual stimulus, some infants exhibited many instances of inattention to the stimulus during its presentation. One possible explanation for some infants not orienting toward the visual stimulus was possibly partial habituation because the six lights were lit simultaneously. Conversely, when the compound stimulus was presented in both modalities (visual and auditory) the participants connected more persistently with the stimuli. The presentation of the visual stimulus to the participants always preceded that of the visual-auditory presentation and the absence of order permutation could have impeached the soundness of the procedure within the experiment. However, the objective of the research was not to compare the efficacy of the visual stimulus with that of the auditory stimulus. The visual modality was the one that delivered the reinforcer commensurately with the compared schedules: conjugate and continuous. The pairing of the auditory modality with the visual one served primarily to bolster participants' responding. Because the auditory consequences did not vary across the schedules of reinforcement, behavioral changes can be ascribed to the visual consequences.

Can the results of this study by extended to infants not directly tested or to other infants in the general population? Or can we expect to find the same results with participants tested in different environments (e.g., laboratory) and by other researchers? The logic used in this study is inductive. Certainly, the results of observations or experiments inductively derived can be couched as universal statements. But induction has its limitations. The statement that all swans are white is derived from multiple observations of swans that are white. "Conditions drawn in this way may also turn out to be false: no matter how many instances of white swans we may have observed, this does not justify the conclusion that all swans are white" (Popper, 1968).

One drawback of this study is that, in its context, except the time designated by the caregiver as the alert or play period of the participants, or their willingness to cooperate, no manipulation may be able to increase the potency of the reinforcer used in the study. There were some where participants, when placed in the experimental condition, did not respond as expected. The effectiveness of the reinforcers was, it seemed, at the mercy of the participants' vagary. In hindsight, it might have been better to use stimulus (e.g., a nursing bottle containing milk) the value of which could be rendered more effective during the period that precedes feeding time. Siqueland (1964) has reported the use of such reinforcing events under mild deprivation conditions where participants did not exhibit fussiness or any aversive behavior.

Rovee and Rovee (1969) have reported a behavioral stability on the part of participants under reinforcement that lasted entire sessions of 46 min. The fact that the participants were tested in a familiar environment—the crib—and positioned as they are usually in the natural environment, might have accounted for the high behavioral persistence they exhibited. The preparation used in this study has not permitted participants' responding in various phases to be recorded in one session. Data collection had to be broken into various sessions because many participants could not tolerate being in the experimental setting for more than 12 minutes. One possible explanation is that infants seldom find themselves in the natural environment seated in an enclosure and facing a series of colored lights. The artificiality of the setting might have contributed to the mild apprehension expressed by some of the participants when placed in the experimental situation. That said, it is problematic to refer to the acquisition rate of the target behavior when session truncation may have disrupted the continuity of responding. Participant 4, for example, exhibited an unexpected drop in responding 24 hours after the first session ended and the second one began.

Pelaez et al. (1997) compared the effects of systematic stroking, tickling, and poking on infant attention and affective behavior, closely paralleling a juxtaposition of the schedules being compared in this study. Poking, tickling and systematic stroking, as a form of touching, were administered to infants and they responded preferentially to the types of touch they experienced (i.e., systematic stroking vs. tickling or poking). Poking and tickling, because of the break in the continuity associated with their delivery, resembled a discrete delivery of touch. In contrast, the uninterrupted movement of a stroke, because of the continuity of the massaging hand to the participants' skin resembled a conjugate delivery of touch. Quite expectedly, during the stroking regimen, infant participants exhibited more instances of positive affect than when they were subjected to treatments of tickling and poking.

The present study is inconclusive, yet can be the springboard that sparks research interest in the direct comparison of continuous and conjugate reinforcement. Future studies might use as potential reinforcers stimuli that can be manipulated (e.g., via mild deprivation) at the opportune time and in an experimental milieu that closely parallels that of the participants' natural environment.

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